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SEIC Approach to Exposure Criteria for Continuous Noise

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Sakhalin Energy Investment Company LTD.

**Noise Management and Mitigation: SEIC
Approach to Exposure Criteria for Continuous
Noise**

**Меры по уменьшению воздействия шума: подход СЭИК к установлению
порогов для непрерывных шумов**

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		<i>[Signature]</i>	<i>[Signature]</i>	<i>[Signature]</i> 19/10/07		

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Noise Management and Mitigation: SEIC Approach to Exposure Criteria for Continuous Noise

October 2007

This briefing note has been developed in response to the recommendation of the western gray whale advisory panel (WGWAP) regarding the real time noise criteria to be used near the Piltun feeding area following the WGWAP-2 meeting in St Petersburg (Recommendation Reference WGWAP 2/016 from WGWAP-2 report, April 2007). The purpose of this briefing note is to specify SEIC's approach to managing the acoustic footprint in the Piltun feeding area as implemented during previous offshore activities as well as for the 2007 PA-B topsides installation, hook-up and commissioning. SEIC believes that their current real time noise criteria, as part of the overall noise mitigation program, provides sufficient protection to the western gray whales on their feeding grounds from sounds generated by offshore construction activities.

SEIC appreciates the input of the panel regarding the definition of sound level criteria for western gray whales that it has received over the past years and SEIC understands the complexity of this issue and the many uncertainties that remain. SEIC would like to provide additional information here in an attempt to clarify SEIC's position and logic behind the current noise mitigation strategy as a means to move forward on this important issue.

Noise management approach

SEIC developed its noise action criteria in 2004/05 to minimize the industrial sounds generated by the 2005 and 2006 offshore construction activities within levels that would meet the impact assessment criteria used at the planning and design stage (see Marine Mammal Protection Plan 2007, Annex 1). These impact assessment criteria used a received level of 120 dB rms re 1 μ Pa as their basis. This criterion was based on literature that reported 50% of foraging eastern gray whales responded behaviourally at this level (Malme 1986, 1988). SEIC also recognized that in the course of its planned construction activity it would be impossible to avoid any behavioural impact on the whales, and hence set a low but nonzero limit for noise induced avoidance behaviour – expressed as potential avoidance of five whales or less. To be able to assess this level of impact from the planned offshore construction activities, a noise management and mitigation approach was developed that includes the following steps (see Marine Mammal Protection Plan, Annex 3, for further details):

- a) Prior to any major offshore construction activity in the Piltun area the acoustic footprint of each operational phase is forecast using a comprehensive acoustic model and detailed information about the planned construction vessel arrangements. The potential avoidance level of the whales is calculated based on predicted abundance of whales within the 120 dB re 1 μ Pa acoustic footprint, using gray whale density data collected over several years from a variety of survey platforms. Any operational phases that do not comply with the avoidance criterion of five whales or less are evaluated and re-designed until the acoustic footprint is reduced to a level where the avoidance criterion is met.
- b) During the execution of the offshore construction activities, the sounds are measured in real time at multiple sites located in the vicinity of the 20m isobath, which constitutes a notional outer boundary of the Piltun feeding area. The levels are continuously assessed against noise action criteria designed to prevent exposure of whales to sound levels in excess of those expected according to the carefully designed construction plans and associated footprints (i.e. when activities deviate from the pre-season plan).
- c) Additional mitigation measures that reduce the overall sound level are promptly adopted in the field in the event that the noise action criteria are approached or reached (depending on the situation these measures could be relocating vessels more to the east, reduce the number of active vessels, etc.).

Anthropogenic sound levels and whale behaviour

The acoustic monitoring conducted in 2005 and 2006 showed that the underwater sound level produced by the CGBS and pipeline installation activities, as measured at the 20m isobath, never approached the lowest of the two noise action thresholds (130 dB and 140 dB re 1 μ Pa) that SEIC adopted in 2005 based on the recommendations of the Interim Scientific Review Panel (ISRP) then advising the company on Western Gray Whale protection issues. In reality, the acoustic levels observed were in general below the model forecasts from the operation planning stages.

Analyses of whale behaviour data from the 2005 season suggested that the levels of noise generated by the construction and research vessels (the latter operating within or very close to the feeding area) did not appear to affect gray whale behavioural parameters such as speed, surface time, dive time and breathing. Predictions from impact modeling indicated that whale distribution shifted 7 to 119 m further offshore for each 10 dB sound increase. This result, however, could be an artifact of the model itself since the residuals illustrated a potential bias toward over predicting distances from shore beyond 1.5 km. In addition, interpretation of the results of preliminary analyses of distribution data suggested that this potential offshore shift was more likely to be attributed to research vessel activity within the feeding area as opposed to construction operations that occurred 7-9 km further offshore (Gailey et al. 2007). Results from other behavioral studies have demonstrated considerable variability in terms of how marine mammals respond to received sound levels, and there are suggested arguments that the context (e.g. source proximity, Tyack & Clark 1998) in which the sound is received might be as important as the sound itself. The western gray whale studies at Piltun have shown that the magnitude of any possible impact was likely to be minimal and short-term and unlikely to have reached thresholds of biological significance. Whales remained within their normal distribution range in the Piltun feeding area and were observed to continually forage in regions closest to the construction activity. From the field observations in 2005 and 2006, there were no obvious indications of disturbance from the construction activity that raised concerns of potential impact to individual gray whales or to the population.

Based on current literature and results from previous construction seasons, SEIC used the existing noise action criteria for 2007 to monitor construction activity, which was an operation very similar in terms of activities and duration to the installation of the PA-B topsides.

WGWAP-2 proposed noise criteria

During the WGWAP-2 meeting in St Petersburg the scientists presented noise criteria for continuous sound sources that they recommended to be used by SEIC during their offshore construction in 2007. These criteria are based on a dose-exposure calculation that assumes that the occurrence of temporary and/or permanent hearing threshold shift and behavioural reactions in whales is triggered by a combination of received sound level and duration of exposure. Starting with a reference threshold exposure of 60 minutes at 130 dB re 1 μ Pa, the proposed progression applies an "exchange rate" of 5dB per doubling or halving of the exposure time as shown in Table 1 below (copied from WGWAP-2/INF 15).

Table 1. Exposure criteria for continuous noise sources.

Time of exposure (min)	Level B – Received level (dB rms re: 1 μ Pa) for <u>start of diagnostics</u>	Level A – Limit for permitted received level for <u>start of mitigation</u> (i.e., halt of operations)
15	140	143
30	135	138
60	130	133
90	127	130
120	125	128
240	120	123
480	115	118

"The extrapolation extends only to 146 dB for high levels, and if this level is ever recorded, mitigation should occur immediately. For low levels, the extrapolation continues down to 100 dB or ambient, whichever is lower".

Rationale for continued use of the 2006 criteria

There are two main types of impacts to whales that can potentially occur from sound exposure due to offshore construction activities: 1) damage to the whale's hearing ability, i.e. permanent or temporary threshold shift (PTS or TTS) and 2) disturbance/displacement, i.e. avoidance behaviour. Based on the current knowledge SEIC is confident that the present noise action criteria, when used as part of its overall noise mitigation approach, provide adequate protection to the western gray whales and will not result in hearing damage and only have the potential for short-term behavioural changes, if any at all. A brief rationale for the SEIC thinking on the criteria implemented in 2006 (Table 2) as opposed to the criteria proposed by GWAP-2 is given below.

Table 2. SEIC criteria used during real time monitoring.

Time of exposure (min)	Received level (dB rms re 1µPa) for diagnostic purposes	Received level (dB rms re 1µPa) for immediate action*
15	136	140
60	130	130
120	127	
240	124	
480	121	
960	118	

- Immediate action is defined as an action that alters operations so that the noise level is reduced. Potential actions have been communicated with the construction teams prior to operations.
- 1) Although the dose-exposure approach *per se* is believed to be appropriate as a biological effect metric for injury related impacts, such as PTS, there is no evidence that this approach applies to behavioural responses of marine mammals. The main reason for this is that the relationship between sound levels and behavioural response is significantly confounded by contextual variables of the sound itself (e.g. proximity) and of the whales (individual sensitivity, history of exposure, activity, etc.). To date there is no field data available that shows clear relations between behavioural responses and received sound levels. This makes the current basis of the proposed criteria that use cumulative sound exposure metrics for behavioural responses questionable.
 - 2) The dose-exposure calculation proposed by GWAP-2 is based on a reference threshold exposure of 60 minutes at 130 dB re 1µPa. There is no scientific evidence available that at this reference threshold a temporary or permanent threshold shift will occur. Due to the absence of cetacean TTS data, the current knowledge is based on studies conducted on bottlenose dolphins and beluga (e.g. Finneran et al. 2000, 2002, 2005, Nachtigall et al. 2003, 2004) and these studies suggest that TTS occurs at much higher sound levels than the suggested 130 dB re 1µPa for 60 minutes.
 - 3) SEL based thresholds vary with the duration of the exposure of an animal to the sound. Whether to use the equal energy rule, which states that equal amounts of cumulated sound energy over time produce the same damage, and implies a 3 dB exchange rate (a 3dB increase in level halves the allowed duration), or a 5 dB exchange rate, which is based on the premise that damage accrued in the ear during periods of high noise is partially repaired during intermittent low noise periods, continues to be a subject of scientific debate in all studies into the appropriate metric for noise exposure in relation to noise-induced hearing loss (Seixas, 2005). Unfortunately, there is limited available literature on permanent or temporary hearing impairment of cetaceans exposed to continuous sounds and the studies that have been conducted have mainly explored the high level thresholds for TTS. Although there is evidence that the sound exposure metric is a suitable predictor of potential impact, uncertainty remains regarding the maximum and minimum thresholds to which this metric applies and the exact relation between dose and exposure. The ongoing debate between the Q=3 and Q=5 exchange rate is evidence of the uncertainties that still exist.
 - 4) It is unknown and not scientifically proven where the low level cut off should occur for the dose- exposure approach. The lower level for an operational halt shown in the table of GWAP-2 criteria is 118 dB for 8 hours, and the accompanying text suggests that levels be

considered down to 100 dB (with an associated exposure threshold of 64 hours for start of diagnostics) or ambient, whichever is lower. SEIC uses as the lower cut-off for immediate actions 130 dB for 60 minutes (in relation to behavioural responses). The field acoustic monitoring team also uses diagnostics levels shown in table 2 to track whether this immediate action threshold may be approaching so that construction teams can be notified in advance and all due mitigation action can be taken.

As for the cut-off level used by SEIC it should be reiterated that the company has acknowledged all along that a certain level of behavioural impact to the whales would arise from their construction activities, without impacts on the population level. As described earlier in this briefing document, the extent of the behavioural impact has been forecast prior to every construction season using a complex acoustic model in combination with all available data on whale distribution and abundance.

Conclusions

Potential damage to the hearing ability of the whales

The current sound pressure level criteria (e.g. US Marine Mammal Protection Act) for onset of TTS are 190 dB rms re 1 μ Pa for pinnipeds and 180 dB rms re 1 μ Pa for cetaceans. It should be noted that the onset of PTS will occur at higher levels. These SPL criteria have been applied to both pulsed and non-pulsed sounds. Based on points 2 and 3 above and the lack of scientific evidence regarding thresholds for PTS and TTS for continuous sounds, SEIC intends to follow international best practice and maintain its criteria at levels that to date have never been documented to be the cause of permanent or temporary hearing impairment.

Disturbance of whales, i.e. avoidance behaviour

There is limited information in regards to how gray whales respond to sound during their foraging periods. As mentioned previously, exposure criteria were based on the known literature available at this time. Behavioural studies on various marine mammal species have indicated that reactions to sound exposure can be more variable and situation dependent than damage to the hearing apparatus. The translation from behavioural responses to potential biological impacts on an individual and/or at the population level is extremely difficult to determine since the result of the response, such as decreased growth, reproductive success, survival, etc, occurs on a much larger temporal and spatial scale than the immediate response to sound (NRC 2005). For the critically endangered western gray whale during the feeding season, special consideration is needed regarding responses that could lead to reduced feeding, displacement, and consequences that can affect their overall health, survival, and reproductive success. As described above, analyses of behavioural data collected during the 2005 offshore construction activities indicated little suggestive evidence of behavioural responses directly related to noise exposure, and the observed correlations were suspected to be more related to research vessels in close proximity to the whales or could be attributed to artefacts of the statistical model (Gailey et al. 2007). In either case, the results of this work placed comfort that there were no large effects in relation to changes of the behaviour of individuals and subsequent population level effects. In addition, there is increasing evidence that patterns in distribution and movement of gray whales in the Piltun area are highly correlated to the distribution of their food resources (Fadeev 2004, 2005, 2006, 2007). Lastly, the population assessments conducted by the IISG in 2005 and the WGWP in 2006 both resulted in an upward revision of the 2004 population size estimate. Although this upward trend needs to be interpreted with caution, it provides some pragmatic evidence that the industrial activities in the region, carried out according to the current noise mitigation approach, appear to have been successful in terms of no deleterious effect on the gray whale population level.

Because the 2007 offshore construction activities (topsides installation, hook-up and commissioning) are very similar in nature as the 2005 CGBS placement, both with respect to sound levels and duration, SEIC is confident that its existing noise action criteria, together with the overall noise mitigation approach, provides sufficient protection of the western gray whale in its feeding area to sound exposures.

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